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Systematic testing of flood adaptation options in urban areas through simulations

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While models can quantify flood risk in great detail, the results are subject to a number of deep uncertainties. Climate dependent drivers such as sea level and rainfall intensities, population growth and economic development all have a strong influence on future flood risk, but future developments can only be estimated coarsely. In such a situation, robust decision making frameworks call for the systematic evaluation of mitigation measures against ensembles of potential futures.

We have coupled the urban development software DAnCE4Water and the 1D-2D hydraulic simulation package MIKE FLOOD to create a framework that allows for such systematic evaluations, considering mitigation measures under a variety of climate futures and urban development scenarios. A wide spectrum of mitigation measures can be considered in this setup, ranging from structural measures such as modifications of the sewer network over local retention of rainwater and the modification of surface flow paths to policy measures such as restrictions on urban development in flood prone areas or master plans that encourage compact development.

The setup was tested in a 300 ha residential catchment in Melbourne, Australia. The results clearly demonstrate the importance of considering a range of potential futures in the planning process. For example, local rainwater retention measures strongly reduce flood risk a scenario with moderate increase of rain intensities and moderate urban growth, but their performance strongly varies, yielding very little improvement in situations with pronounced climate change. The systematic testing of adaptation measures further allows for the identification of so-called adaptation tipping points, i.e. levels for the drivers of flood risk where the desired level of flood risk is exceeded despite the implementation of (a combination of) mitigation measures. Assuming a range of development rates for the drivers of flood risk, such tipping points can be translated into anticipated time spans over which a measure will be effective.

While the new simulation setup is limited to situations where the planner is able to define realistic ranges for the development of drivers of flood risk, it certainly contributes to an improved consideration of deep uncertainties in the planning process. Future work will particularly focus on the application of the framework in a variety of urban development contexts.